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by
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October 1979

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PREFACE

This is an extended version of a paper presented at the American Psychological Association meetings in New York, 1979.

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USER GUIDES: SOME THEORETICAL GUIDELINES FOR THEIR USE

ABSTRACT

Recognitional capacity is needed in order to perform tasks: a recognition of when procedures apply. Further, recognitional capacity cannot be replaced by higher-level procedures. This creates an insurmountable barrier for guidebooks that attempt to provide step-by-step procedural accounts of task performance. User guides will be most successful when they attempt to show novices how to perform procedural tasks. However, step-by-step user guides will be least successful when applied to tasks involving recognitional capacity, with the goal of developing high levels of proficiency. The information gathered will be voluminous and difficult to present, but will also be criticized as insufficient. It is suggested that the way to overcome the barrier presented by recognitional capacity is by approaching it directly, perhaps as a type of analogical inference, rather than by trying to decompose it into more procedures.

USER GUIDES: SOME THEORETICAL GUIDELINES FOR THEIR USE

The objective of this paper is to explore some of the theoretical limitations of user guides. Specifically, I will try to show that step-by-step approaches cannot be followed for the performance of certain types of tasks and are not useful for describing high levels of proficiency.

User guides can serve a variety of functions. They can describe characteristics of equipment. They can serve as memory aids. They can be step-by-step, how-to-do-it directions. In this paper, I am only addressing user guides that are step-by-step directions intended to tell a person how to perform a task skillfully. Examples of such user guides: how to repair an engine, how to fly an airplane, how to cook an omelette, how to monitor a contract, how to solve problems. I am not going to deal with user guides that try to improve skills by providing exercises (e.g., chess problems to solve), or by suggesting other forms of instruction. I am only concerned with attempts to break a skill down into its components, and then to present these components as steps to be followed.

Often, psychologists, educators, engineers, and human factors specialists are called upon to prepare explicit user guides. Many times, a conflict will arise about how specific to make the guide. The people representing the users may argue that a very specific guide is needed, so the user will know just what to do, and when. Anything less may be too vague to be useful. The people charged with developing the guide will argue against such a cookbook approach. They may claim that the specifics are not known. Sometimes, they will propose a multi-year program of research to gather the data. The users may

suspect the developers of laziness, incompetence, and willful noncompliance. The developers may suspect the users of being unreasonable, naive, and rigid. Rather than choose sides here, it may be helpful to examine some of the basic assumptions behind user guides.

User guides (i.e., step-by-step descriptions) rest upon the assumptions that (a) the skilled performance of a task can be analyzed into procedures, and (b) these procedures can be presented in a guidebook to be followed. Are either of these reasonable assumptions? Can performance be broken up into voluntary actions? The task of preparing user guides raises issues that are fundamental to psychology and philosophy. For we begin to ask questions about the nature of knowledge, and whether the knowledge underlying skilled performance can be expressed in terms of procedures.

This paper is organized into two sections. First, I will explain why some aspects of performance cannot be analyzed into procedures. Second, I will explore some of the barriers this creates for step-by-step types of user guides.

I. Can skilled performance be specified as procedures?

Weitzenfeld (1974) has argued that while all knowledge is analyzable into assertions that are true or false, the application of these assertions presupposes the ability to recognize instances when they are called for. And this ability, which Weitzenfeld calls a recognitional capacity, cannot be specified in terms of procedures to be followed.

When a task is presented as a set of rules or procedures[1] to be followed, the problem is that novices do not recognize when to

[1] Statements of the form "if X occurs, do Y in order to produce Z."

apply these procedures; they are insensitive to the experiential/ contextual factors governing selection/application/modification of procedures.

Now, everything would work out if we could tell the novice when to apply the procedures--if we could give higher-level procedures to guide the application of the lower-level ones. But I don't think we can. To see why, let's consider a chess example. Let's say a grandmaster writes a book of chess principles, and one of them is to keep the king protected. Fine, that's good to know, if I am a novice. But if I am playing at a reasonably proficient level of performance, then the guidance isn't enough. I need to recognize when and how it applies. It makes sense to keep my king protected in the middle of the game, but in the end game I may want my king out there helping my pawns race down the board, and intercepting my opponent's pawns. I also have to know how to apply the principle--how to keep my king protected. For the novice, this usually means keeping as many friendly pieces in front of the king as possible, an approach that has all the subtlety and finesse of trench warfare during WWI. As we gain in proficiency, we recognize that "protect" involves keeping the king secure from the various combinations and sacrifice attacks available to our opponent.

Now, the question is: can we take this ability of the proficient chess player to recognize when and how to protect the king, and translate it into higher-level procedures for the novice? I don't think so. One reason is that if I can be told when and how to protect my king, then the principle: "Protect your king," becomes trivial. I shouldn't have to worry about it anymore. If I can recognize when my king is and isn't protected, then I don't need the principle "Protect your king." The second reason is that the grandmaster's skill in

recognizing when and how to protect the king is more like a perceptual recognition than a higher-order procedure. It reflects training, experience and contextual factors, and the ability to perceive a new situation as similar to ones already understood (Dreyfus, 1972; Weitzenfeld, 1974; Klein, 1977, 1978).

So, guidebooks are useful for teaching a complete novice some easily applied, non-contextual principles of chess, but they are of less value for teaching high level chess, where skill depends on recognitional capacity rather than on procedures to be followed. That is why for a given position, a grandmaster considers only about two-to-four moves, whereas most top-level computers consider over 30 moves. The skill of the grandmaster is in recognizing which moves to analyze. Computer programs must resort to brute force to do what the grandmaster does in "zeroing in" to promising moves. Interestingly, while beginners study books of principles and find them helpful, masters study actual games.

I am not saying that there are no procedures to give to the novice. There are, and they can be very helpful for a variety of tasks. I am attacking the assumption that all tasks can be described in terms of steps to be followed, and that novices are performing these steps slowly and inaccurately whereas experts are performing the same steps quickly and accurately. I am instead claiming that some aspects of skilled performance, i.e., recognitional capacity, cannot be described in terms of steps that can be followed, but depend on training and experience. The skill of a proficient performer does not break down into procedures, and so step-by-step guidebooks won't be able to teach skilled performance.

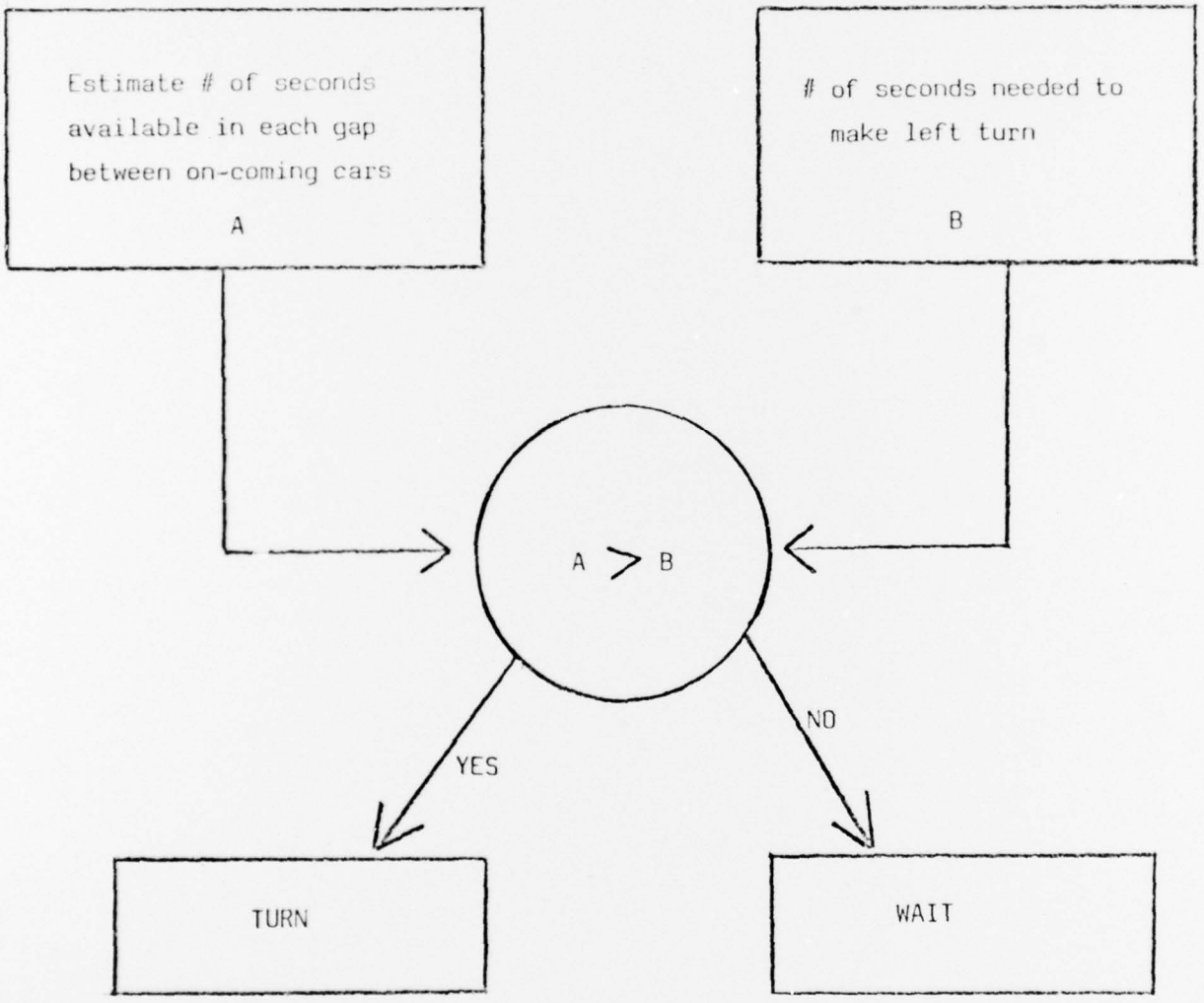
Skill also involves a familiarity with our own abilities, gained through experience. When you attempt to substitute higher-order procedures for recognized self-capacity, you run into problems of circularity. That is because you are trying to present guidance to a novice about how to perform a task, but the guidance could only be understood by someone who is no longer a novice.

For an example of this, think about what kind of guidance you would give a novice driver, who was having trouble making left turns into opposing traffic. This is a real problem for beginners, in part because their turns are slow, and in part because they are variable. One turn may take 2 seconds, and another 10 seconds as they misjudge the angle, saw back and forth, backup, and recover.

To present guidance, in the form of step-by-step procedures, we might evolve a flowchart such as Figure 1. But there are several problems with this. First - how is the novice going to estimate (A), which involves estimating distances and speeds of cars and translating them into seconds available? Second - what value will the novice use for (B) - number of seconds needed? If novices use the number of seconds needed by an experienced driver, they are going to get hit a lot. If they use the number of seconds it takes them on 90% of their turns, then you are just ratifying what they usually do, not giving them guidance for improving their performance. And third, if people could estimate (A) and (B), they wouldn't be novices. Novices are people who don't know how well or accurately they will perform. People who can perform these estimates don't need the guidance. The circularity is introduced when you try to replace experience and recognition with

FIGURE 1

FLOWCHART FOR DECISION TO MAKE LEFT-HAND TURN



procedures that still presuppose recognition.[2]

So, in response to the question "Can skilled performance be specified in terms of procedures?" the answer appears to be "no." All tasks depend on recognitional capacity, and this is built up through experience. There are ways of training it, but not of replacing it by procedures.

II. Barriers to Guidance

If knowledge of how to perform a task cannot be decomposed (into steps, rules, sub-tasks, procedures), then we have identified a barrier to user guides. (For a fuller treatment of many of the points discussed below, see Klein, 1977, 1978). With regard to step-by-step user guides, the theoretical limitation described in the last section should be manifested in two ways: (a) a restriction on the tasks that can be described, (b) limitation of audience to novice levels of proficiency.

(a) Restriction on the tasks that can be described. Tasks vary in the extent to which they rely on recognitional capacity. For some tasks, recognitional requirements are simple; for others, they are complex and rely heavily on contextual factors. Step-by-step descriptions work for tasks that are largely procedural, such as starting a jet engine. The switch movements are reasonably straightforward, and the contextual framework is limited, so recognitional capacities are not very important. The airplane is sitting on the ground, in as standardized a condition as it will ever be.

[2] I am not claiming the proficient drivers follow the procedures in Figure 1 - quite the reverse. The experienced driver isn't following any procedures. Can you estimate the values for (A) and (B)? I doubt it. Yet you have no trouble recognizing when a suitable gap exists for turning left. It could be argued that the rules are so well learned that they have become unconscious and automatic. But then why would people have trouble calculating and using the values on a conscious level, and why would their conscious use interfere with performance? And how do we tell the novice about rules and procedures that should only be used unconsciously?

The tasks that will not be successfully described in terms of step-by-step procedures are those for which skilled performance depends on complex recognitional capacity. Examples of such tasks are: making a decision, catching a ball, maneuvering against an opponent. When we try to proceduralize such tasks, we often wind up with steps that don't mean anything. Montemerlo and Harris (1978) have presented a facetious example of procedures that have to be followed in painting masterpieces: 1) Think of a great idea; 2) Sketch it out; 3) Fill in the colors and details; 4) Check it over and make any necessary alterations.

Contextual understanding allows experts to resolve ambiguity. But guidebooks cannot afford to assume that their users have an adequate contextual understanding (if the users did, they would not need the guidebooks). So ambiguity is resolved through more rules and procedures. But context *is not just more* rules or pieces of information. It is the framework within which the task is performed, and within which it must be understood. A practical barrier that is encountered in trying to handle contextual frameworks by additional rules and procedures, is the need for voluminous amounts of information which are still deemed insufficient. A burden this creates for guidebooks is that of presenting and cross-referencing additional information.

A concrete example is the guidance provided for Instructional Systems Development (ISD) personnel. ISD is a task analysis of how to do task analysis. It presents the steps needed to break complex tasks down into steps. Montemerlo and Harris (1978) have documented the growth of ISD manuals from fair-sized single volumes in the late '60s to the massive multi-volume models of the mid-'70s. But no one can apply massive multi-volume models (which are still criticized as having insufficient detail). According to Montemerlo and Harris, ISD is a "judgemental" task

(i.e., dependent on recognitional capacities) and thus not amenable to its own methods of task analysis.

(b) Limitation of audience to novice levels of proficiency. It is hard to describe the procedures someone must follow to become proficient at a task, because proficient performers are not aware of following procedures; attempts to make them follow procedures can interfere with their performance.

Proficiency seems to depend on forgetting about rules and advice, such as the procedures presented in step-by-step guidebooks. If you had to estimate (A) and (B) in Figure 1, would that help or interfere with making left turns? A person giving a piano recital who is thinking about a book "Piano Playing Made Simple," is in trouble.

I have been arguing that proficient performance doesn't consist of following procedures. The reverse is also true: Procedural tasks do not seem to lend themselves to highly proficient levels of performance. You would not say that someone was a real expert at starting a car under standard conditions. Of course, if we are talking about <u>your</u> car, and getting it started on cold winter mornings, when you have to listen to its gasps and sputters and know just how much to tease it with the choke or accelerator, then we are dealing with complex recognitional capacity, and expertise is possible.

I have implied in this section that in order to determine whether a procedural description of performance (such as ISD or Job Performance Aid (JPA) approaches) will be useful, we must consider two dimensions. The first is whether the task is procedural (requiring simple recognitional capacities), or whether it depends on complex recognitional capacities. (This also has implications for the amount of information to be presented.) The second dimension concerns the target population: are

we trying to improve the performance of novices, so they can achieve a low level of competence under standard conditions, or are we trying to help adequate performers become highly proficient?

Tasks that are procedural (i.e., insensitive to contextual variations) and require novices to become minimally adequate will be most easily and successfully handled by user guides.

III. Conclusions

User guides are often attempts to provide cookbook (i.e., procedural) approaches to performance. Cookbook approaches don't work in statistics -- they teach the procedures for calculating a formula, but leave the student baffled about when to apply the formula. Cookbook approaches do not work for teaching deductive logic. Students learn how to set up a Venn diagram, but don't know how to apply this in a new situation (unless they can recognize that it is like a specific problem they have already done). Cookbook approaches don't work very well in cooking either. They can help a novice make a reasonable approximation of a dish. But their value to the proficient chef is as a checklist reminder about ingredients and operations. The operations presuppose recognitional capacities, and for this reason are beyond the skill of novices.

I am proposing that disagreements between users and developers of guides can be resolved by a more careful analysis of the nature of tasks involved, the type of audience, and the level of skill development expected.

Sir Peter Medawar has stated that "To deride the hope of progress

is the ultimate fatuity, the last word in poverty of spirit and meanness of mind." I am arguing that current task analysis approaches will be unsuccessful except when dealing with procedural tasks and novice levels of proficiency. I hope that this does not represent poverty of spirit and meanness of mind. I feel that it is important to recognize limitations of paradigms in advance of their demonstrated failures, so that alternate approaches can be developed.

One potential strategy in developing an alternate approach would be to focus on the nature of "recognitional capacity." I have not defined recognitional capacity except to say that it is presupposed by procedural types of knowledge, and that it can not be replaced by higher-level procedures. Recognizing when a procedure applies in a new situation may sometimes involve recognizing that the new situation is similar to some previous situation, especially in complex situations. This recognition of similarity may be useful for directing performance. The selection and use of previous situations to direct performance in new situations, is the phenomenon of reasoning by analogy. Thus, it may be possible to extend some current work on analogical inference (e.g., Weitzenfeld & Klein, 1979) to provide principles of guidance for the learning of complex tasks. (But it should not be possible to devise step-by-step analogical procedures.)

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